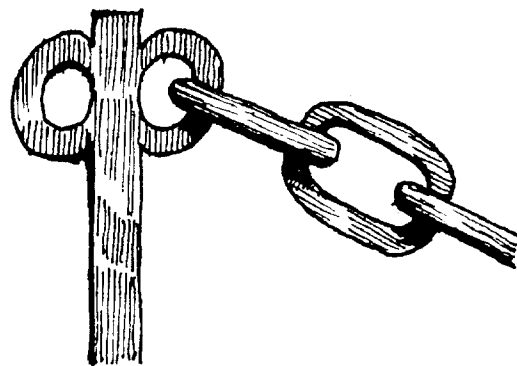


Metals: General

Metal items associated with the coastal fortifications around San Francisco Bay include iron and structural steel in the form of steel beams and other structural shapes, reinforcing steel in the form of twisted, billeted, and deformed bars, imbedded steel items and hardware, metal handrails, metal doors and windows, and anchors and connectors. The use of structural metal items changed with the development of concrete construction, particularly from the late nineteenth century to the beginning of World War I. Imbedded metal items and hardware such as maneuvering rings and anchoring plates changed little. Handrails evolved from small square bar rails and chain rails to pipe rails with threaded connections.

Causes of Deterioration:

1. Corrosion: Iron, steel and other metal may suffer from corrosion due to chemical and electrochemical reactions which cause the metal to oxidize or combine with chemicals such as carbonates or sulfides. The salt- and moisture-rich environment of the coastal fortifications is particularly hard on metals. Contact between dissimilar metals can also cause electrochemical reactions.
2. Fatigue: Structural iron and steel may be subject to metal fatigue due to excessive loading, repetitive movement due to wind loading, or stress from cyclical loading. Harmonic movement from wind loading and seismic movement can also cause fatigue.
3. Impact: Equipment and vehicles impacting structural metals can cause localized damage that can lead to further deterioration and failure.
4. Lamellar Tearing: Tearing at welded joints results from improper welding practices.
5. Loose Connections: Structural steel joints and connections may loosen due to impact, vibration, or stress on connectors and anchors such as bolts and nuts.



Detail. Iron stanchion and chain rail.

Identification:

The detection of metal deterioration is best accomplished by a structural engineer. However, many problems are visible through careful and systematic inspection. Whatever symptoms are found, professional evaluation is recommended. The signs of metal deterioration include:

1. Wearing away of metal surfaces.
2. Cracks, especially at points of maximum stress.
3. Localized distortion, twisting, or bending.
4. Paint or coating failure (an indication of underlying metal stress).
5. Misalignment.
6. Lack of plumb or level, sagging, or deflection.
7. Rusting or staining.
8. Loose bolts, rivets, or other connectors.
9. Broken welds.
10. Visible movement.

Inspection and Testing:

Inspection can identify deleterious conditions and distinguish among the various materials and conditions but testing and laboratory analysis may be required to identify hidden conditions, particularly those within masses of concrete. Such testing may be required where structural failure has occurred or where failure is eminent. This type of testing is best recommended by a corrosion or structural engineer. Testing methods include the use of ground-penetrating radar, x-ray analysis, and sonic penetration.

Metals: Structural Iron and Steel

Structural iron and steel items include I-beams, angles, channels, rails, bars, and smooth, twisted, deformed, or billeted reinforcing bars. Structural iron and steel, where exposed, should be inspected regularly and treated promptly to prevent further deterioration.

Replacement of Deteriorated or Damaged Members:

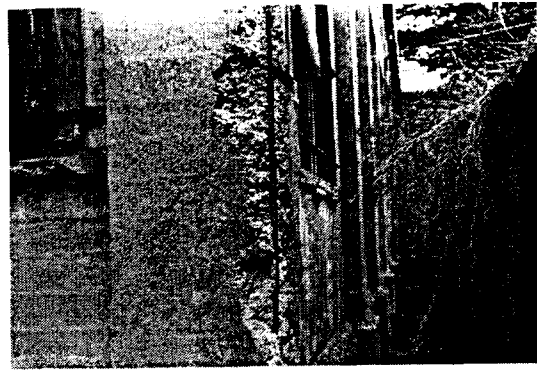
Replacement of structural items should be a last resort to prevent structural failure or damage to adjacent historic fabric. Replacement should be with similar materials if hidden and with matching materials if exposed.

Repair of Deteriorated or Damaged Members:

Repair of structural metal, in place, is preferable to removal and replacement. Surface patching and filling should be done with metal fillers such as automobile repair compounds.

Prevention of Corrosion:

Corrosion is prevented by removal to bare metal and the application of appropriate protective coatings. Sandblasting, or gritblasting, is the preferred method of removal of rust and corrosion from steel but may cause damage to wrought and cast iron. Gritblasting should be limited to specific areas of corrosion and adjacent areas protected with plywood. Where metal items such as doors can be removed, it is preferable to remove the item and gritblast and prime coat the item in protected shop conditions. After cleaning to bare metal, the metal surface should be wiped with a solvent and a primer should be immediately applied. Priming should be followed by finish painting with at least two coats of approved paint material applied according to the manufacturer's written instructions. A single manufacturer for the primer and top coats is recommended to insure compatibility. Specific painting and coating treatment is addressed in Finishes: Wood and Metal Coatings.



Battery Dynamite power plant. Spalled concrete and exposed rebar.

Relief from Excessive Loading:

Excessive loading of structural beams such as I-beams or reinforcing steel can be reduced by reducing the loading or by adding additional supports to transfer or redistribute the loading. Plant growth, vegetation, and trees, and trapped moisture can contribute to loads in overhead earthworks. Additional supports, in the form of support columns and plates can be useful in transferring loads. Additional supports should be designed by a structural engineer and carefully placed to avoid punching shear or point loading where bearing capacity is inadequate.

Connectors:

Bolts, nuts, rivets, anchoring plates, and other connectors should be inspected. All loose connectors should be tightened and monitored. Replace missing connectors.

Metals: Imbedded Hardware

Imbedded metal items include wrought iron maneuvering rings, brass hinges, window bars, and other miscellaneous fittings. These items are set into concrete or masonry either being cast-in-place or attached to cast-in-place anchors. Imbedded metal items can have corrosion problems that can affect the masonry or concrete into which they are set. Weakened planes can form around the imbedded item and can contribute to cracking and spalling.

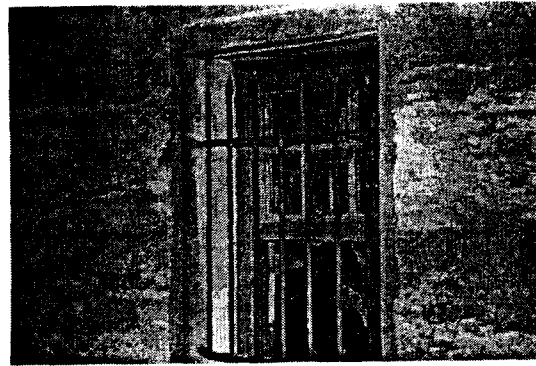
Wrought Iron Maneuvering Rings:

Wrought iron maneuvering rings are set in concrete on walls adjacent to fortification gun positions. The rings were designed to be used in the placement and setting of guns on their mounts. The rings are in good condition and require only regular inspection, cleaning, and protective coating.

Hinges:

Brass pivot hinges are set in concrete walls adjacent to masonry openings and support iron strap hinge assemblies attached to wood or metal doors. The brass hinge portion is in direct contact with the iron hinge portion and the electrochemical reaction causes corrosion and efflorescence. Treatment should be directed at isolating the two incompatible metals. For efficiency, treatment of the doors should be coordinated with isolating the metals.

1. Remove metal or wood doors from hinges.
2. Clean brass hinges free of efflorescence using an approved chemical cleaner and brass wool.
3. Install a solid neoprene gasket and sleeve over the brass hinge portion.
4. Rehang door. Treatment and repair of doors is covered in Doors and Windows: General; Treatment for Doors; and Hardware.



Battery Duncan. Double-hung window at traverse wall showing grill with decorative points.

Window Bars:

Hand-fabricated, wrought iron and steel bars are installed in some window openings. The openings are in masonry or concrete walls. The bars are simple vertical rods set on horizontal bar stock which is anchored into the concrete at the window jambs. The bars are flattened at the top ends to form a decorative "spear point" design. The bars have suffered vandalism in the form of bending and distortion. In some cases bars have been removed. Anchorage of the horizontal bars in jambs has become loose. Treatment involves removal of the bars, reworking in a metal shop, and reinstallation. Repair concrete and masonry jambs if required.

For restoration purposes, removal of window bars and other imbedded items may be required. When bars are loose, the metal may be heated sufficient to bend the metal, or cut for removal. Where inset metal has already caused spalling or masonry deterioration, break out additional material, repair metal, reinstall, and patch masonry.

Metals: Handrails and Guardrails

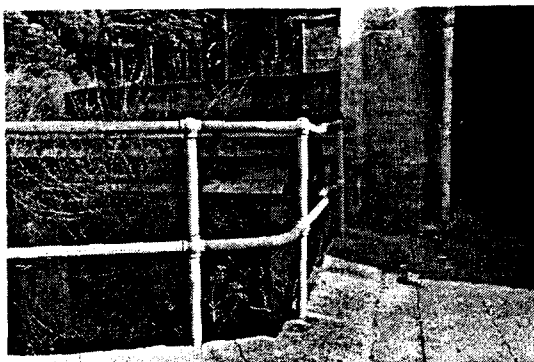
Handrails at the fortifications are of three types: Solid square wrought iron bars, chain rails, and pipe rails. Few of the early square section bar rails and chain rails from the Endicott and Taft periods are extant, although many examples of pipe rails remain intact. Retention of existing original metal railings and installation of new railings to replace missing elements is important for safety and as character-defining features. The square-section railings are set in sleeved holes cast into the concrete. The risers for the rails are set in cement or molten sulfur grout. Pipe rails are set in escutcheon plates bolted to risers at the concrete. In some cases, piperail uprights are screwed into escutcheon plates bolted to concrete. Rails are connected by four-ways, elbows, and Ts. The joints are threaded. Original pipe rails were primed and painted.

Treatment:

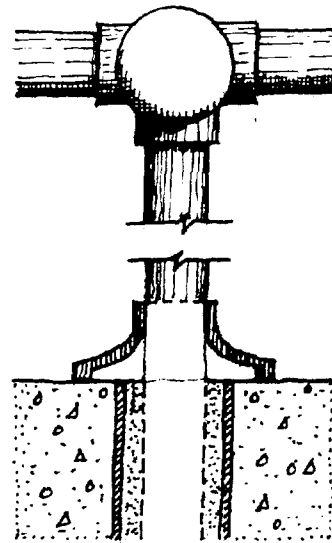
Railings should be repaired or replaced to meet standards that require railings to resist a lateral load of 200 pounds at any point along the rail.

Existing Railings:

1. Tighten all joints at screwed or bolted connections. Replace bent or severely deteriorated components to match original materials. Verify secure anchorage.
2. Gritblast metal railings and wipe down with solvent to remove residue and flash corrosion.
3. Prime immediately and paint.
4. Wrought iron bar rails and chain rails require solvent cleaning and waxing.



Battery Kirby. Handrails.



Typical pipe rail detail.

New Railings:

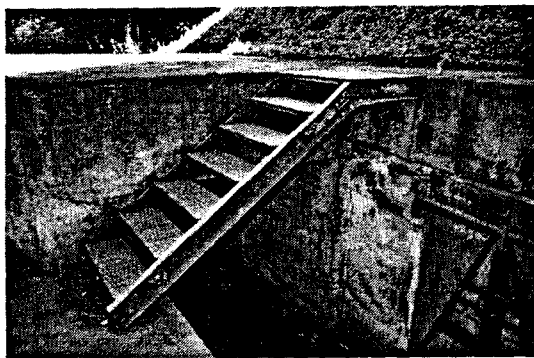
1. Design new railings to match existing original railings. Pipe railings are typically two-inch outer diameter, thick-walled, black iron piping with cast ornamental ball joint connectors. Railings are anchored into pipe sleeves cast or drilled into the concrete and grouted in place. The joint between the pipe and concrete is covered with an escutcheon plate and screwed in place.
2. Fabricate railings as specified from pipe of the proper diameter. Ball joint connectors may require special casting. Rails are to be shop primed.
3. Install new railings. Clean out existing sleeves and set railings plumb and level. Grout in place using a non-shrink metallic grout. Install escutcheons.
4. Fabricate wrought iron bar rails and stanchions for chain rails from mild steel to match original construction.

Metals: Ferrous, Miscellaneous

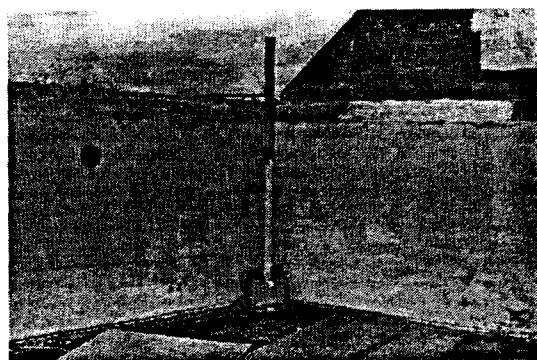
Miscellaneous metals includes military hardware attached to or set in the fortifications. Items include gun mounts, armored conduits, surface mounted boxes for electrical and communications equipment, ammunition handling equipment and other items.

Treatment:

1. Clean metal item free of dirt, oils, debris, corrosion, and deteriorated paint.
2. Brush or clean to bare metal or to stable paint level and wipe with solvent.
3. Secure anchorage devices.
4. Apply approved coatings.



Battery Marcus Miller. Steps leading from loading platform to working platform.



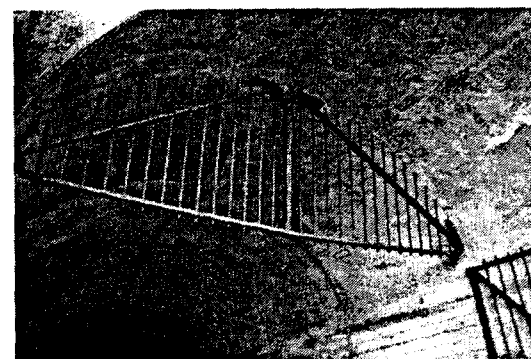
Battery Crosby. Emplacement one, support for camouflage, corner of loading platform. Note also, ventilator opening to left; heavy asphalt coating on floor.



Battery Marcus Miller. Counterweight cable pulley for ammunition hoist doors.



Battery Stotsenburg-McKinnon. Ammunition supply tramway and turntable in central corridor between pits.



Battery Construction #129. Emplacement two, grill above entry gates.

Carpentry: General

Carpentry includes both rough and finish carpentry associated with wood framing, wood finish surfaces, and trim. Carpentry work is limited at the fortifications to light wood framing, wood doors, windows, and frames, wood roof decking, and wood siding. Some associated structures had wood floors and beaded board ceilings.

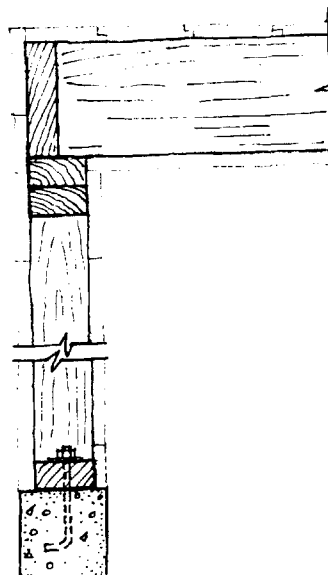
Causes of Deterioration:

Sources of wood deterioration are primarily associated with moisture. Secondary sources include excessive loading, wind loading, abrasion, and vandalism.

Moisture: Moisture infiltration can deteriorate wood through the growth of destructive fungi. Fungi induced rot requires a host material (wood), air, a stable temperature, and moisture content above twenty-five percent. Rot is found in two forms: soft rot, a surface decay caused by moisture saturation and alternating wet-dry cycles; and brown rot, or dry rot, a pervasive decay having a crumbly appearance. Fungi can be transmitted by contact and by airborne spores.

Excessive Loading: Excessive loading can cause deflection which can weaken structural wooden elements. Common causes of deflection are the mounting of equipment on structural members that are not designed for the loading and lack of diagonal bracing. Wind loading, especially high, intermittent winds, can loosen connections allowing moisture penetration.

Abrasion: Wind blown sand can abrade wood surfaces and the coatings that protect them.



Detail. Typical basic wall and roof framing section showing plates, studs, headers and joists.

Identification:

Deterioration of wood elements may be identified by the following signs:

1. Presence of moisture.
2. Staining or discoloration of wood.
3. Presence of mildew or fungi.
4. Presence of soft rot or brown rot.
5. Soft or spongy wood.
6. Loss of wood material.
7. Sawdust-like debris and insect droppings.
8. Structural deflection of wood members, lack of plumb or level.
9. Paint deterioration on wood members.
10. Deterioration of applied finish materials.
11. Sagging, buckling, cupping, or bowing of wood members.
12. Loose connections.

Inspection and Testing:

Inspection for moisture-related deterioration in wood involves systematic and thorough on-site investigation. Most moisture problems are readily observed. Further investigation requires the use of a sharp probe to penetrate wooden elements in order to detect soft spots that may be hidden by paint or the outer wood surface.

Carpentry: Treatment

Eliminate sources of moisture infiltration

such as roof leaks, failed waterproofing, gutter and downspout leaks, coating failure, standing water, and inadequate surface drainage. Dampness and the accumulation of moisture vapor should be reduced by the installation of adequate ventilation of interior spaces.

Removal and replacement of a deteriorated wood elements

may be required in cases of severe damage or where structural integrity has been degraded. Removal and replacement may require removal of covering finish material. Replacement of original historic materials should be considered only if other means have been exhausted. While it is best to replace deteriorated material with materials that match, it may not be possible to obtain exact matching materials. Substitute materials should be carefully evaluated and selected on the basis of closeness of match, durability, and structural requirements. High grade pine and fir are usually safe selections for most replacement conditions. Redwood and cypress are appropriate where moisture resistance is required but structural requirements are minimal. Pressure treated wood is appropriate for high moisture conditions that include contact with the ground.

Repair by attachment of additional structural elements.

Scab onto existing deteriorated wood elements, add blocking or additional nailers. In some cases new wood elements can be used to bridge across deteriorated members in order to distribute structural loads. Where visual appearance is important, new wood materials may be pieced in (or let in) by cutting out deteriorated portions and fitting in new wood to match that removed.

Repair of individual deteriorated

members can be accomplished by removal of the deteriorated portion and repair with epoxy filler. A variety of epoxy repair products are available including putties and low viscosity penetrating consolidants. Epoxy resins can be mixed with fillers such as pea-gravel, sand, or sawdust and used to fill voids in original wood. Deteriorated wood should be carefully removed and the area to receive patching materials cleaned and dried. In some applications forms or dams may be required to retain the epoxy mix until it sets up.

The application of protective coatings to deteriorated wood should be carefully considered. While application of such coatings may prevent moisture penetration, some coatings may trap moisture within the wood and cause further deterioration. Select products that are "breathable" and follow manufacturer's written instructions.

Materials and Equipment:

1. While **new materials** should match original materials to the greatest extent possible, standards for new wood materials include:
 - PS 20 "American Softwood Lumber Standard"
 - SPIB (Southern Pine Inspection Bureau)
 - WCLIB (West Coast Lumber Inspection Bureau)
 - WWPA (Western Wood Products Association)
 - APA (American Plywood Association)
 - AWPBS (American Wood Preservers Bureau Standards)
2. Moisture content of **replacement lumber** should not exceed nineteen percent.
3. For **structural uses** lumber should be graded and marked appropriately. Structural grade yellow pine or fir are recommended.
4. **Special molding profiles** may not be commercially available for some wooden elements. When commercial sources have been exhausted, it may be necessary to fabricate router knives to match some wood profiles. Router knives should be retained for future use.

Moisture Protection: Causes of Deterioration

Moisture protection includes the repair or application of new protective coatings and membranes to existing surfaces. Waterproofing is applicable to vertical and horizontal surfaces except for exposed roofs and includes surfaces below grade and under earthworks. On the fortifications asphaltic waterproofing was applied to concrete and masonry surfaces below grade and under earthworks and was protected with hollow clay drainage tile. The tile had the dual role of protecting the waterproofing membrane and providing a drainage conduit for moisture that accumulated around the structure. (In some cases, cobble stones were used as drainage coursing.)

Waterproofing products are in the form of trowel-applied asphaltic or bituminous coatings; expansive sheet goods such as bentonite panels; penetrating chemicals; and membranes such as modified bitumen, butyl, and elastomeric.

Historic methods include trowel-applied asphaltic coatings, and parging with cement paint or a cement plaster wash.



Battery Godfrey. Cold joint displaying sheet lead as waterproof layer. Stained concrete from imbedded metal elements.

Deterioration frequently occurs when one or more of the following changes have occurred on site:

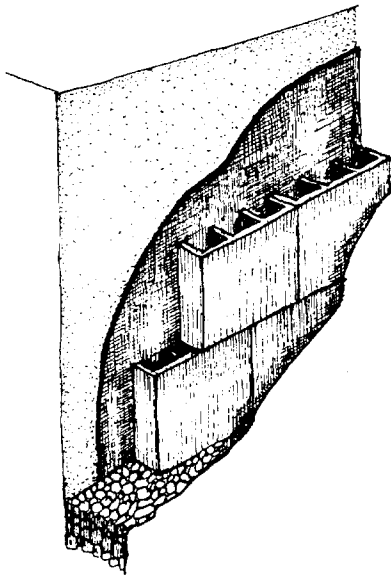
1. Waterproofing deteriorates through degradation of materials. As sacrificial coatings, waterproofing materials normally deteriorate.
2. Waterproof coatings are breached by structural movement, cracking, and penetration by mechanical means.
3. Grade changes adjacent to a protected surface can expose the edges of the waterproofing to the elements and cause subsequent deterioration.
4. Grade changes adjacent to a protected surface can be such that the exterior finish grade at the structure is above the level of the waterproofing and surface water can flow into a wall.
5. Original application of the waterproofing may have been faulty; too thickly applied; too thinly applied; inconsistently applied; incompatible with the substrate; or deficient in workmanship.
6. Asphaltic built-up roofs deteriorate due to direct exposure to moisture and the subsequent degradation of materials. In addition, asphaltic built-up roofs deteriorate due to exposure to wind, rain, and sunlight. Deterioration of the roof deck and deficiencies in the original installation are also contributory to roof deterioration.

Moisture Protection: Identification and Testing

Identification

Moisture problems often occur when the following conditions exist:

1. The presence of moisture on interior walls and floors.
2. Obvious active leaks.
3. High humidity inside a structure.
4. Exposed edges of waterproofing materials.
5. Exposed surfaces of waterproofing that show thinness, drying, cracking, or material loss.
6. Mold, staining, efflorescence, or fungi on wall surfaces.



Typical detail, Endicott & Taft periods. Exterior waterproofing: asphaltic troweled-on coating on concrete protected by split clay tile. Tile cavity is for drainage to gravel course below.

Inspection and Testing:

Inspection of waterproofing at the fortifications requires the removal of earthen cover to expose vertical and horizontal surfaces. Selective excavation should start where waterproofing is exposed to view at its edges and corners.

1. Remove enough fill to expose a sample area that includes the top and bottom edges of the waterproofing. Inspection of interior surfaces corresponding to exterior waterproofing locations can be useful in discovering moisture infiltration.
2. Examine cold joints, cracks, and penetrations for dampness or the presence of water, staining, or efflorescence. The use of a calibrated moisture meter is useful when moisture penetration routes are not clear.
3. Grid the interior surface into four-inch squares with a level and chalk line. Take moisture readings at the grid points and graph readings to locate moisture sources.

Note: Infrared remote thermal sensing can also be used to locate moisture penetrations and accumulations. Wet areas appear as thermal anomalies because wet areas retain heat in contrast to drier areas.

Moisture Protection: Treatment

Procedures:

1. Perform testing and on-site investigation to determine the extent of moisture infiltration.
2. After the extent of the moisture infiltration has been identified and located, remove fill from the exterior of the structure adjacent to the problem area and expose the surface of the waterproofing. If the top edge of the waterproofing is below grade, regrade adjacent to the top edge. If trenches adjacent to the structure must be left open for repairs, provide interim drainage or make provisions to pump out any accumulated water.
3. Perform demolition of deteriorated waterproofing materials down to a stable and clean substrate. Repair cracks and seal penetrations.
4. Prepare the surfaces to receive waterproofing according to waterproofing manufacturer's written instructions. Allow substrate and primers to dry thoroughly.
5. Apply waterproofing to the prepared substrate. Application should be according to manufacturer's written instructions. Coordinate the entire installation with adjacent finishes, sealants, and other work.
6. Allow proper curing of the waterproofing before replacement of any protective tile, installation of drainage fill, or backfilling of trenches. Monitor the installation of the waterproofing to insure that moisture penetration has been eliminated.
7. Where historic clay drainage tile is uncovered, store tile properly during waterproofing work and reinstall when work is complete. Carefully backfill to hold tile in place. Where tiles are missing, replace with salvaged tile or substitute material.

Materials:

1. Sheet Membrane Waterproofing:

Mechanically applied or adhered to substrate, these membranes are rubberized sheet stock, elastomeric, or expansive mineral sheets such as bentonite.

2. Fluid-Applied Waterproofing:

Fluid-applied material is directly applied to a substrate which forms an elastic surface membrane.

3. Bituminous Damp-Proofing:

Hot- and cold-applied damp-proofing is surface applied by trowel and minimizes moisture infiltration.

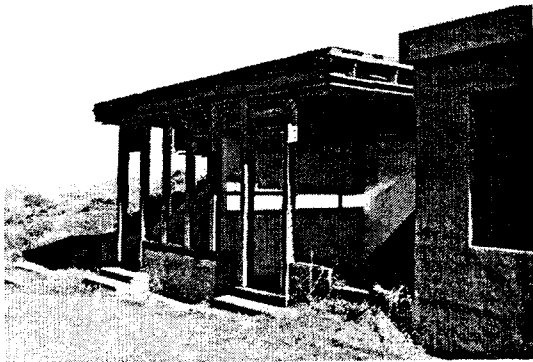
4. Water Repellents:

Clear silicones, acrylics, and other penetrating chemicals are surface applied and consolidate either on the surface or within the material to prevent the passage of moisture.

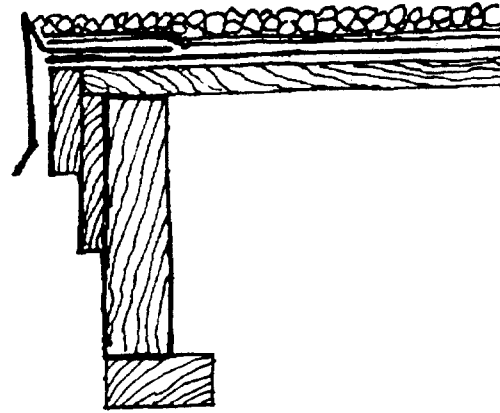
Moisture Protection: Built-Up Roofing

The use of built-up roofing is limited to isolated structures associated with the fortifications. Existing built-up roofs are multiple-ply, tar and gravel installations that are in very poor condition.

All existing roofs require complete replacement. After repairs to roof substrates (wood decking) new built-up roofing should be installed as follows: Mechanically fastened modified bitumen unsurfaced roll roofing with torched seams over manufacturer approved base sheet. Ballast should match original local gravel. Coordinate installation with wood trim, flashing, and roof penetrations.



Battery Spencer, emplacement two. Remnant of latrine superstructure showing cross section of built-up roof. Oil room to the right.



Detail. Cross section showing roof deck, base sheet, roofing membrane, gravel ballast, and gravel guard.

Doors and Windows: General

Doors and windows at the fortifications include slab wood doors with metal bracing, solid plate metal doors with metal bracing, standard wood panel doors in wood frames, wood sash double-hung windows in wood frames, and fabricated metal combination awning, hopper, and casement windows. Wood and metal slab doors are the most common exterior door types. Wood panel doors are limited to interiors and to support structures. Wood windows are very limited. Metal windows, although also limited in number, range from factory manufactured industrial metal units to shop fabricated metal frames and stops used with protective metal shutters. Most doors and windows are in poor condition. Some metal doors have been welded shut for security reasons and some masonry openings have been closed with plywood or metal sheeting.

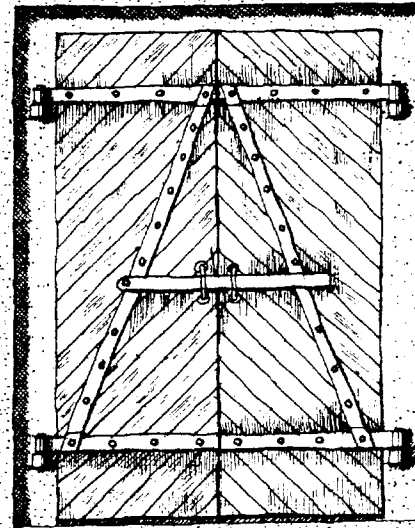
Hardware includes hinges, strap braces, hasps, eyes, and other shop-built devices. Interior wood doors are fitted with standard butt hinges, mortise locks, and knobs.

Causes of Deterioration:

1. Exposure to moisture.
2. Loose hardware.
3. Lack of interior ventilation.
4. Vandalism.
5. Loss of protective coatings.

Identification:

1. Corrosion, rusting, and staining.
2. Rot.
3. Deterioration of coatings.
4. Loss of materials.
5. Loose hardware.
6. Missing parts.
7. Separation of panels, stiles, rails, and frames.



Detail. Exterior wood slab door on metal angle frame. Wood boards are bolted to steel angles and flat bars. Metal strap hinges are attached to bronze pivot hinges.

Inspection and Testing:

Inspection should begin with a survey to document all doors and windows in the fortifications. Each door and window should be measured, photographed, and assessed. From the field data, develop a door schedule, window schedule, and a hardware schedule. Group doors, windows, and hardware by type. From the schedules, develop a work plan that maximizes shop repair procedures, material purchases, and setup time. A systematic approach can save time, money, and can yield valuable information about a significant and highly visible historic building component.

No laboratory testing or analysis required.

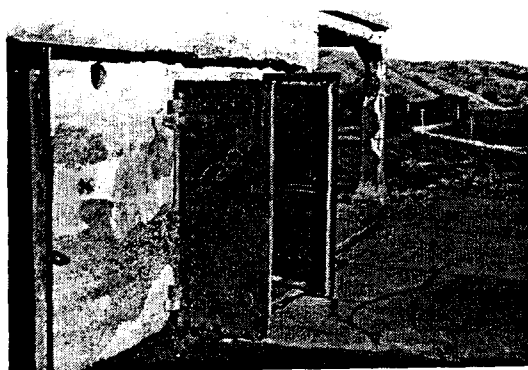
Doors and Windows: Treatment for Doors

Slab Wood Doors:

1. Remove door from opening and provide a temporary and secure closure.
2. Remove deteriorated wood elements and replace with matching materials such as ship lap and beaded board. Use redwood or treated pine. Wood joints should be coated before joining. Repair existing salvageable wood elements. Prime wood surfaces.
3. Shield wood surfaces and gritblast metal surfaces to bare metal. Wipe metal with solvent and prime.
4. Repair bolts and rivets and tighten all connections. Spot prime all bare spots.
5. Repair and rework hardware.
6. Apply finish paint coats in shop.
7. Repair opening to receive repaired door. Patch deteriorated concrete edges; remove debris, vegetation, and accumulated fill around door; and insure proper drainage.
8. Repair inset brass pivot hinge section by cleaning, removal of efflorescence, and installation of neoprene washer. Sheathe to pintle to isolate dissimilar metals.
9. Reinstall door, secure, and monitor condition.

Solid Plate Metal Doors:

1. Remove doors to shop.
2. Gritblast to bare metal and wipe with solvent.
3. Repair surface deterioration and prime entire unit.
4. Repair and rework hardware.
5. Apply finish coats in shop.
6. Repair opening to receive reworked door. Remove debris, vegetation, and fill. Insure proper drainage around door.
7. Repair inset brass pivot hinge section and clean free of corrosion and efflorescence. Install neoprene isolation washer and sheath.
8. Reinstall door, secure, and monitor.
9. Where metal elements are deteriorated beyond repair, complete or partial replacement may be required. Replacement materials, techniques, and configuration should match original construction.



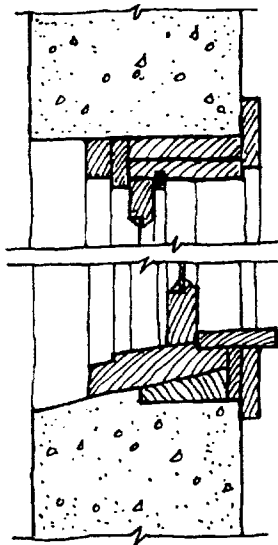
Battery Mendell, emplacement one. Steel doors for truck access. Note deterioration at base of door. Also spalling at drip mold and splinterproof columns.

Wood Panel Doors:

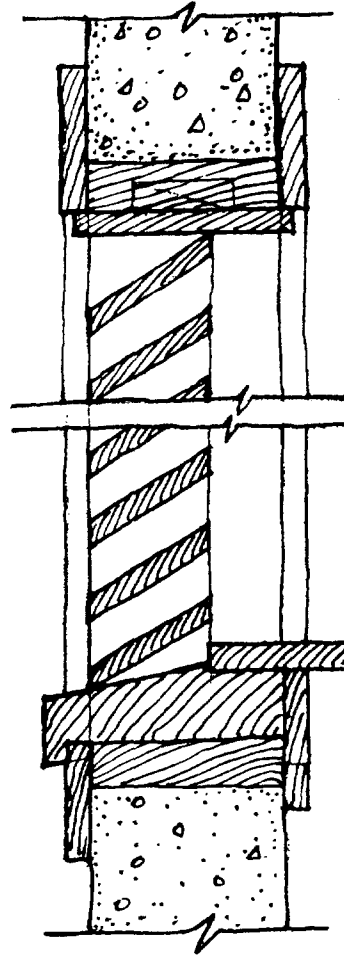
1. Remove wood panel door to shop.
2. Repair door by replacing deteriorated stiles, rails, or panels.
3. Remove deteriorated paint to bare wood or stable paint layer.
4. If severely deteriorated, fabricate new matching door unit.
5. Prime door and coordinate placement of hardware. (Reuse existing hardware or match with replica hardware.)
6. Apply finish paint coats.
7. Reinstall door in repaired opening and frame, secure, and monitor.

Doors and Windows: Treatment for Wood Windows

1. Remove window sash to shop.
2. Repair by replacing deteriorated stiles, rails, and muntins, or replace with a replicated shop-fabricated sash to match. Reglaze windows with new glazing, glazing points, and compound. Shop prime.
3. Apply finish coats in shop.
4. Rework window frames replacing deteriorated materials or missing parts and paint.
5. Reinstall window. (Window repair should be accomplished in association with a secure building that is weather tight. Interim protection requires the installation of a painted plywood covering.



Detail. Typical head and sill section of double-hung wood window.



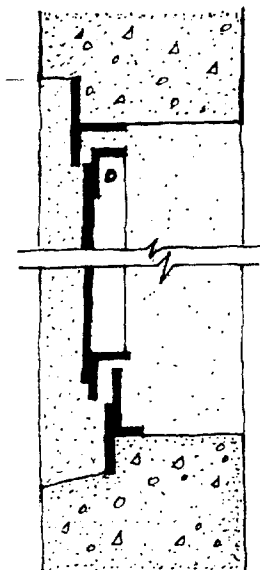
Detail. Typical louvered wood window in concrete opening.

Doors and Windows: Treatment for Metal Windows

Treatment:

1. Determine the condition of the metal window and determine the level of repair required. If rust is found to be only surface corrosion the normal maintenance procedures may be sufficient. If rust is found to be moderate and only penetrates into the metal enough to distort the metal's surface, then repair in place is called for. If rust permeates the metal and causes delamination, extensive repairs in place and/or removal to a shop may be required. Other conditions, including the method of attachment, may determine the extent to which steel windows may be repaired in place.
2. Clean window sash and metal frames. Remove dirt, loose paint, and surface rust.
3. Determine level of repair or if complete replacement is required.
4. After surface rust has been removed by use of sandpaper, wire brush, or gritblasting wipe bare metal with solvent and spot prime with a zinc-rich, rust-inhibitive primer. Coordinate spot priming with overall surface preparation. Metal elements that have lost at least fifty percent of their thickness due to rust will require replacement.
5. If reglazing is required, remove glass and glazing compound. Scrape metal to bare metal. Metal should have one primer coat and one finish coat of paint before reglazing.
6. If metal is bent, bowed, or misaligned reform or realign the metal. Pressure, or heat and pressure, may be required to straighten deformed metal. Severely deteriorated sections of the sash may be removed and newly fabricated elements welded in place. Steel window frames are usually set into adjacent masonry or concrete and are difficult to remove.
7. Replace any missing hardware, screws, bolts, operators, or other fittings.
8. Make window operational so that it opens, closes, and swings freely.
9. Coordinate window repairs with appropriate weather protection materials.

10. Provide temporary security with painted plywood panels.
11. Seal joints between metal frame and adjacent masonry or concrete with an elastomeric sealant.
12. Repair and paint metal shutters and associated fittings.



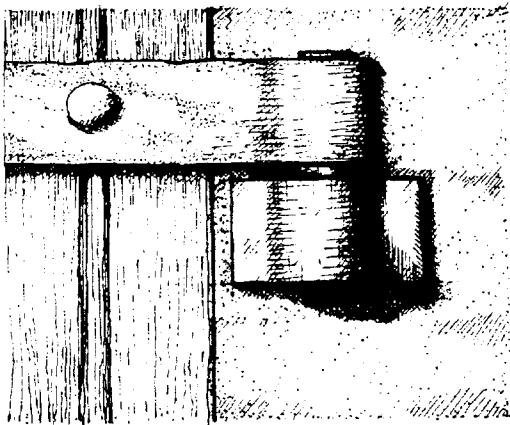
Detail. Metal window shutter showing head and sill condition.

Materials:

- | | |
|---------------|--|
| Steel: | Cold rolled mild steel one-eighth inch thick. |
| Gritblasting: | Small grit (#10-#45) at eighty to 100 psi pressure. |
| Fillers: | Epoxy fillers with high fiber content and auto body patching compound. |
| Primer: | Zinc-rich, rust-inhibiting primer compatible with finish paints. |
| Paint: | High gloss alkyd exterior enamel formulated for metal. |

Doors and Windows: Hardware

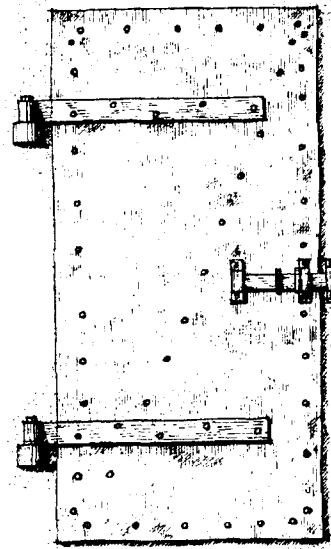
Hardware includes hinges, hasps, eyes, mortise locks, knob sets, and associated fittings. The utilitarian nature of most hardware at the fortifications is typical for military architecture. Much of the hardware items for exterior slab and metal plate doors at the fortifications is shop fabricated for use with pad locks. More formal hardware is seen on wood panel doors.



Detail. Typical exterior door hinge. Iron strap attached to brass pivot hinge base set in concrete. Beaded boards are riveted to the strap. Contact between the iron and brass is creating electrochemical corrosion.

Treatment:

1. Tighten hinges and all fasteners attaching hardware to doors. Make sure that all hinge-pins are in place.
2. Clean, prime, and apply rust-conversion coating.
3. Clean and lubricate all locking devices.
4. Fabricate new hardware to match original. Shop fabricate items where original hardware is missing.
5. Install isolation gaskets at hinges.



Typical metal exterior door. Sheet iron riveted to angle frame. Note that strap hinges are set on bronze pivots set in concrete. Custom-made slide latch.

Finishes: General

Finishes include both interior and exterior coatings. Interior finishes include paint and whitewash on concrete, masonry, metal, and wood. Exterior finishes include camouflage coatings for concrete; and, paints for concrete, metal, and wood. Also included in this section are graffiti removal, and signs and stenciling. Finish coatings at the fortifications are utilitarian and follow typical military painting patterns. Of special note are the concrete coatings developed for camouflage. These coatings were prototypical and represent early experiments in camouflage techniques. Although in poor condition, many examples of camouflage coatings remain. Some recent attempts to paint out graffiti have altered the appearance of some fortification structures.

Causes of Deterioration:

1. Improper or inadequate surface preparation.
2. Moisture infiltration behind paint layers.
3. Weathering and the hostile marine environment.
4. Incompatibility between primer and finish coats.
5. Improper paint application.
6. Improper paint selection.
7. Use of poor quality paint materials.
8. Uneven paint coverage.
9. Paint application during adverse weather conditions.
10. Overpainting.

Identification:

1. Presence of mildew.
2. Chalking.
3. Crazing.
4. Cracking.
5. Intercoat peeling.
6. Solvent blistering.
7. Wrinkling.
8. Peeling.
9. Alligatoring.
10. Fading.
11. Suction spotting.
12. Flaking.

Inspection and Testing:

Inspection and testing are critical to identify historical paint coatings and colors. Historical mix design is documented in engineering reports and coordination between historical descriptions and formulae with extant finishes is essential to preserve original coating materials. To accomplish the preservation of existing historical coatings and to restore fortifications to their appropriate appearances, it is recommended that a master paint schedule be developed. The extent of the paint work at each fortification should be documented. Samples should be taken and matched to standardized paint chips. Coordinate all paint investigation and removal with applicable regulations concerning hazardous materials, especially lead-containing paints.

Finishes: Exterior Concrete Coatings

The determination of conditions and corrective procedures is complicated by the need to match historic paint colors, the need to preserve historic painted surfaces, and the requirement to do no harm to the substrate. The development of a comprehensive approach to the preservation of historic surface coatings and the installation of new painting is advisable.

Identifying Historic Concrete Coatings:

Historic concrete coatings were designed to camouflage exposed concrete so that it would blend with surrounding terrain. During the Endicott and Taft periods, 1885-1916, camouflage was experimental as both a military concept and as a coating for concrete, an emerging building material. Camouflage was designed to work when viewed from the sea. With the advent of military aviation, camouflage was required to work when viewed from the air. Camouflage coatings for concrete were developed in the late nineteenth century and remnants remain on the concrete at a number of fortifications. Historical concrete camouflage coatings were required to hide the stark new concrete work. Some coatings described in the *Annual Reports of the Chief of Engineers, U.S. Army*, from the period, include:

- 1896: Lampblack/cement wash applied with a whitewash brush.
- 1898: One coat of boiled linseed oil; one coat mineral brown in oil.
- 1899: Cement and water mixed to the consistency of whitewash, with Pecora stain, yellow ochre, and lampblack mixed in to create a color matching adjacent spoil banks.
- 1902: Two coats of brown metallic paint.
- 1903: Two coats of boiled linseed oil was allowed to be absorbed by the concrete; a third coat consisting of oil and Prince's metallic brown was applied and, while still wet, screened, dry sand was swept over the surface.
- 1913-1945: Pigmented cement paints and black asphalt emulsion paints. Colors for World War II camouflage include greens, ochre, and brown and can be seen at Batteries Dynamite, Wallace, and Townsley, respectively.

Treatment:

It is important to preserve remnants of historic surface coatings, particularly those pigmented coatings that represent early efforts at camouflage. It is preferable to retain the historical coatings, even in a deteriorated condition, than to remove historical finishes in the interest of applying new replicated finishes. Oil-based coatings proved, shortly after being installed, to be detrimental to concrete. If any replicated finishes are to be used, they should be oil-free.

To Preserve Historic Concrete Camouflage Coatings:

1. Remove deleterious conditions that contribute to coating deterioration including: vegetation, sources of moisture, and adverse structural conditions.
2. Fully document remaining examples of surface coatings showing location and extent. Review historical photographs. Record existing coatings with large format color photography.
3. Take samples for analysis and determine colors.
4. No further action is required for stabilization or preservation.

Finishes: Interior

Historic interior finishes for the fortifications included both paint and whitewash. Paints included both oil-based enamels and pigmented cement paints. Whitewashed surfaces proved to be very durable in that they allowed for the migration of moisture.



Battery Mendell. Remnants of wall finish and wooden wiring chase.

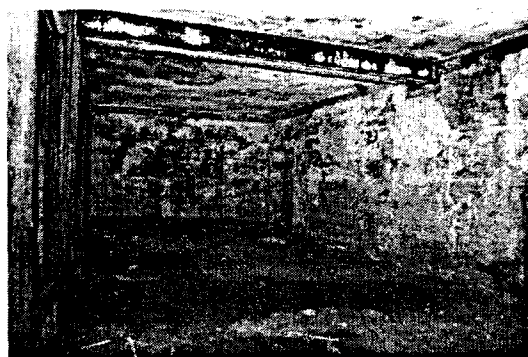


Battery Spencer. Finishwork for the fireplace in the commanding officer's room. Dependent structure.

Treatment:

1. Remove deleterious conditions that contribute to paint or whitewash deterioration such as vegetation, trapped moisture, and defective moisture proofing.
2. Fully document interior painted surfaces showing the location and extent of paint work. Photograph interior painted surfaces using large format color photography and take samples for color matching.
3. Remove loose paint carefully with a soft paintbrush after documentation.
4. No further action is required for stabilization or preservation.
5. Whitewash: Remove loose whitewash carefully using a soft paintbrush. The historical mix (1899) for whitewash was:

one barrel lime
one pound bluing
one pound potash
ten pounds Russian tallow (animal fat or lard)



Battery Kirby. Interior of plotting room. Remnants of wall and ceiling finishes. Note accumulation of mud on floor.

Finishes: Wood and Metal Coatings

Wood

Wood materials include windows, slab doors, interior wood doors, and trim. Wood materials are limited at the fortifications. The most common wood elements are the slab wood doors built to metal frames.

Treatment:

1. Remove all loose paint, mildew, and other foreign materials from wood. Use sanding, scrapers, or other hand-held devices to remove paint. Removal to bare wood is preferred. However, removal to a stable paint layer is acceptable.
2. After paint removal, wipe wood down with solvent to remove dust.
3. Paint with an anti-fungal primer.
4. Lightly sand dry primer and wipe down with solvent before applying finish coats.
5. Apply two finish coats of approved anti-fungal paint.

Metals

Metals requiring painting include handrails; ladders; inset metal items; structural steel; metal doors; iron strap hinges and door bracing; metal windows, grilles, vents and gun mountings. Historical metal coatings changed little from 1900 to 1945. Red lead was the preferred primer. Linseed oil-based enamel was the typical top coat. While paint technology has improved greatly since World War II, technological improvements have barely compensated for the removal of lead from paints for environmental reasons. Red lead paint was universally accepted as the standard primer of choice for metals. New, environmentally neutral, paint systems are available and offer satisfactory results when combined with thorough surface preparation.

Treatment:

1. Remove all deteriorated exterior paint on metal by gritblasting, brushing, or other approved means. Where paint is in good condition remove loose paint down to a stable paint layer. When gritblasting, clean down to bare metal surface.
2. After blasting or abrasive cleaning, wipe surfaces down with solvent to remove flash rust and prime immediately.
3. Prime with zinc-rich primer or rust-inhibitive primer according to manufacturer's written instructions.
4. After the primer is dry apply two coats of exterior enamel finish coats.

Notes:

1. Use a paint system from a single manufacturer.
2. Do not paint brass, bronze, wrought iron, or cast iron. Wrought iron door closures and hinges are best treated by wiping with solvent and applying microcrystalline wax. See Doors and Windows: Hardware.
3. Consider the use of high-performance coatings such as urethane or epoxy.

Finishes: Graffiti Removal

Graffiti removal methods should be evaluated according to a thorough investigation of the condition of the substrate, the type of media used in the graffiti, and the requirements of the interpretive program. Graffiti removal should be accomplished by the method least destructive to the substrate. Where graffiti ranges from large areas of multiple layers of painting to small areas with a single coating, removal methods should be tailored to suit the situation. Develop a comprehensive graffiti removal program and utilize technical representatives from product manufacturers.



Battery Dynamite, emplacement three. Graffiti at rear corner, showing entry to cross-gallery. Also note debris accumulation and unique profile of sidewall.



Battery Dynamite. Graffiti in cross-gallery, looking toward entry doors for emplacement one. Also showing significant floor deflection as a result of seismic action.

Methods:

1. Abrasive measures include hand and mechanical sanding, scraping, low pressure waterblasting, and gritblasting. Gritblasting should only be used for metals.
2. Thermal methods include the use of heat guns or irons to soften paint for removal by hand scraping. Thermal methods should be used with care due to the potential for fire.
3. Chemical methods include surface-applied chemical compounds, spray-applied chemicals, poultices, and neutralizing rinses. Chemical methods should only be used by skilled technicians after testing and subsequent to the approval of a sample panel.
4. Low pressure steam cleaning methods may be appropriate in certain cases after testing and sample approval.

Note:

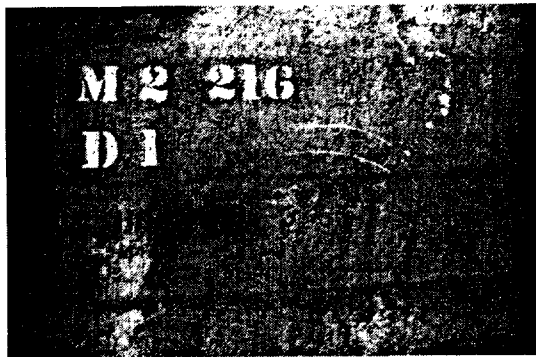
Some graffiti, such as names and dates scratched or written on historic materials, may be historical and worthy of preservation.

Finishes: Signs and Stenciling

The fortifications and associated structures retain the military markings of their periods of use in the form of painted signs and stencils. These markings are important records of how the facilities were used and are character-defining features.

Documentation:

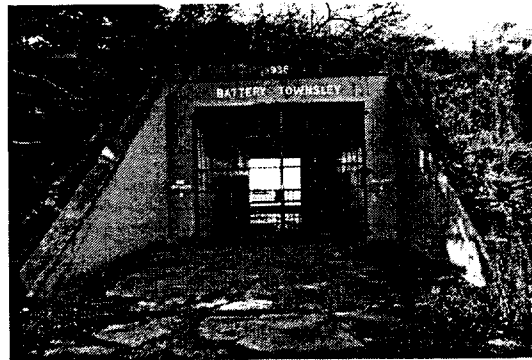
Each stenciled or lettered sign painted on concrete, metal, wood, or masonry should be identified, photographed, and recorded. This work can be accomplished by trained volunteers under proper supervision. Records of signage should be placed in site files and coordinated with periods of military use.



Typical military identification stenciling on concrete wall.

Treatment:

1. Do not attempt paint removal near historic signage.
2. Do not paint over existing historic signage.
3. Develop a comprehensive approach to stabilize, preserve, repair, or restore signage.
4. The best approach to treatment for signage is to reduce the effects of deterioration caused by moisture and vandalism.



Battery Townsley. Identification signage.

Special Items: General

The following listing of special items associated with the fortifications includes equipment, fitting, fixtures, and mountings that either remain intact, partly intact, or are missing from the fortifications due to salvage or vandalism.

Mounted Equipment:

- Generators
- Pumps
- Compressors
- Engines

Military Hardware and Fittings:

- Guns
- Gun mounts
- Anchor bolts
- Hoists
- Ammunition conveying devices
- Sighting devices, instruments, and mounts

Ventilation:

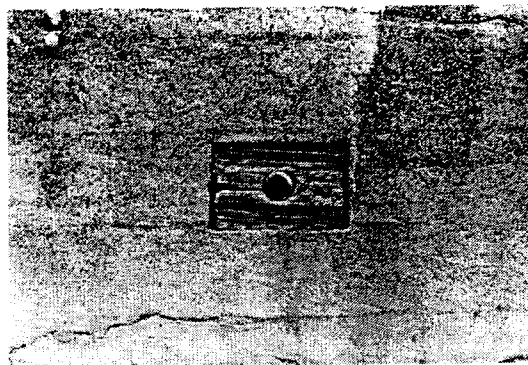
- Vents
- Grilles
- Fans
- Ducts
- Vent stacks and caps

Mechanical Equipment and Fixtures:

- Plumbing piping
- Plumbing fixtures
- Plumbing fittings

Electrical/Communications Equipment and Fixtures:

- Electrical panels and switches
- Electrical conduits, wiring, and boxes
- Electrical fixtures
- Communications equipment and panels
- Communications conduit and wiring
- Speaking tubes



Battery Crosby. Speaking tube face with wooden sign plate.

Causes of Deterioration:

Causes of deterioration are predominantly related to salvage, moisture, and vandalism. See other sections for treatment of specific materials.

Identification:

The presence of special items should be documented for each site and an inventory included in each site folder. The items should be photographed and manufacturer's identification plates and markings recorded.

Inspection and Testing:

Testing is limited to measurement of air flow for interior spaces for ventilation design and implementation.

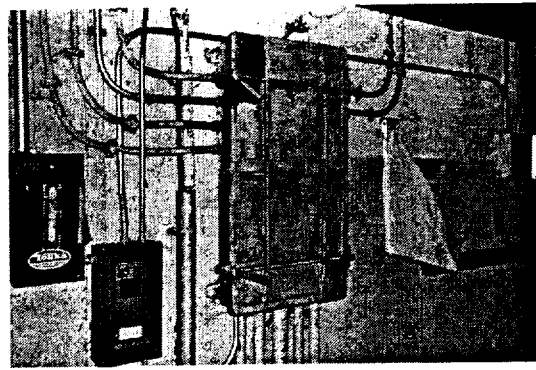
Special Items: Treatment

All special items require appropriate treatment based on their material. Where historic systems such as electrical lighting or ventilation are to be made operable, it will be necessary to repair existing equipment and install replicated or similar fixtures or fittings.

Ventilation:

A primary cause of deterioration at the fortifications is a lack of adequate ventilation of interior spaces. The accumulation of moisture above the ambient humidity of the marine environment can only be dispersed by cycling moving air through the spaces. Some fortifications had provisions for ventilation, either by gravity/convection or mechanical means. When the fortifications were in use, activity which opened doors helped to vent the spaces. However, closure of interior spaces for security reasons has caused moisture to be trapped inside the spaces. Recognizing the need for interior spaces to be closed for security reasons, it will be necessary to provide alternate means of ventilation.

1. Where existing air intakes and outflow grilles or vents exist at fortifications, they should be cleaned and made operable. Where the ventilation system was based on gravity and convection, make sure air circulation paths are clear. Where mechanical systems were used and grilles for intake and outflow remain (and power is available), install exhaust fans on timers or instruments designed to measure relative humidity to provide regular ventilation. Place fans inconspicuously.
2. Where no provisions for ventilation were a part of original construction, either install inconspicuous gravity vents and/or institute a regular ventilation schedule as part of maintenance operations where doors are opened and portable fans powered by portable generators are placed to provide ventilation.



Battery Stotsenburg-McKinnon. Pit A interior, electrical panel.

Electrical Systems:

Where electrical power is required, bring electrical lines to the site underground. Place meters, disconnects, panels, and switches inconspicuously. Where historic lighting is to be reactivated, use existing conduit where possible. Where armored conduit and explosion-proof fixtures were used, provide either matching materials or restored original fixtures.